ONVENTION ISSUE

SECOND QUARTER 1958
Vol. 4, No. 2

ENVIRONMENTAL QUARTERLY

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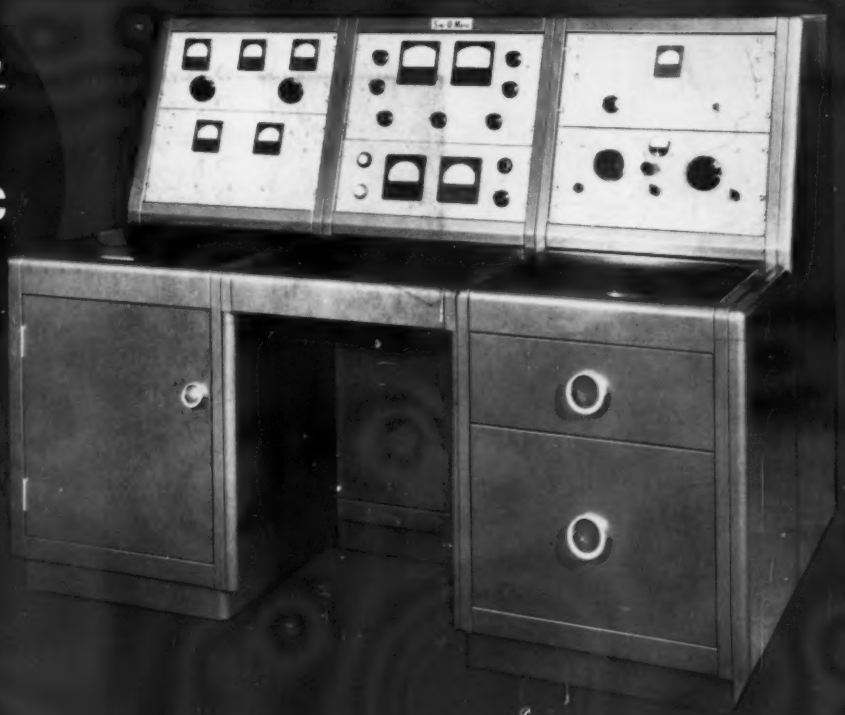

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Vol. 4, No. 2 Second Quarter 1958

CONVENTION ISSUE

Environmental Endurance Testing — Key to Reliability? 8

by A. S. Richardson, Jr., M. I. T.

"The specification qualification test is not a sufficient safeguard of component reliability," the author says.

Production Environmental Testing 14

by Robert Lusser, Redstone Arsenal

Mr. Lusser claims that "production environmental testing" is a dangerous fallacy and advocates replacing it with comprehensive Test-to-Failure programs.

Notes on Simulated Service Testing 20

by Ellsworth F. Seaman, Navy Bureau of Ships

Mr. Seaman explains some basic philosophies, and raises a number of questions about how we can better relate the results of simulated laboratory testing to actual field conditions.

New Officers of the IEE 17

Handbook Project Develops Thrust 27

Outstanding committee formed. First volume expected by mid-summer. Free to IEE members.

Editorial — The Search for Reliability 6

Rudkin of Arma Wins Prize for N. Y. IEE Chapter 4

EEI to Develop Cost Reporting System 26

Local Chapter News - Los Angeles Chapter Forming 22

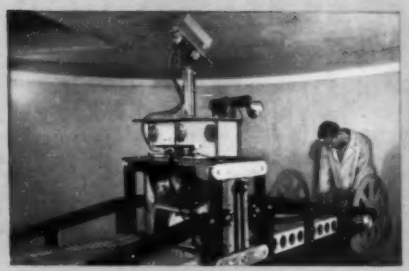
The General Manager Speaks • 4

Developments • 12

New IEE Members • 31

New Products • 34

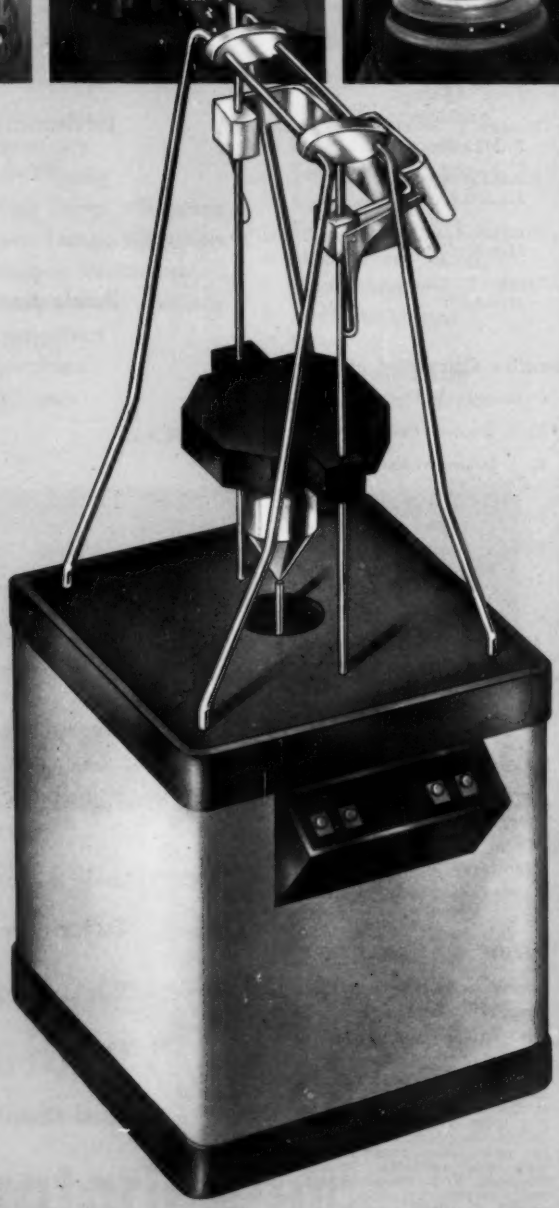
Avco introduces two new devic or



sawtooth pulse shock machine

Developed by Avco Research and Advanced Development Division to meet testing specifications for the Air Force *Titan* ballistic missile program, this versatile machine develops a sawtooth shock pulse which rises to 100 g's in six (6) milliseconds. Its application also extends into many other types of shock testing for MIL-E-5272A. The pulse is not limited to sawtooth types but can be varied to meet other shock testing requirements simply by changing the shape of the lead pellet upon which impact is made. This machine's size and compact design permit efficient operation and ease of handling.

Avco's Lycoming Division is now setting up production to meet increasing demands for this shock machine, the first to meet the sawtooth shock wave specifications for ballistic missile testing.



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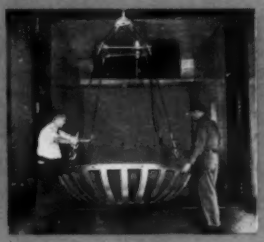

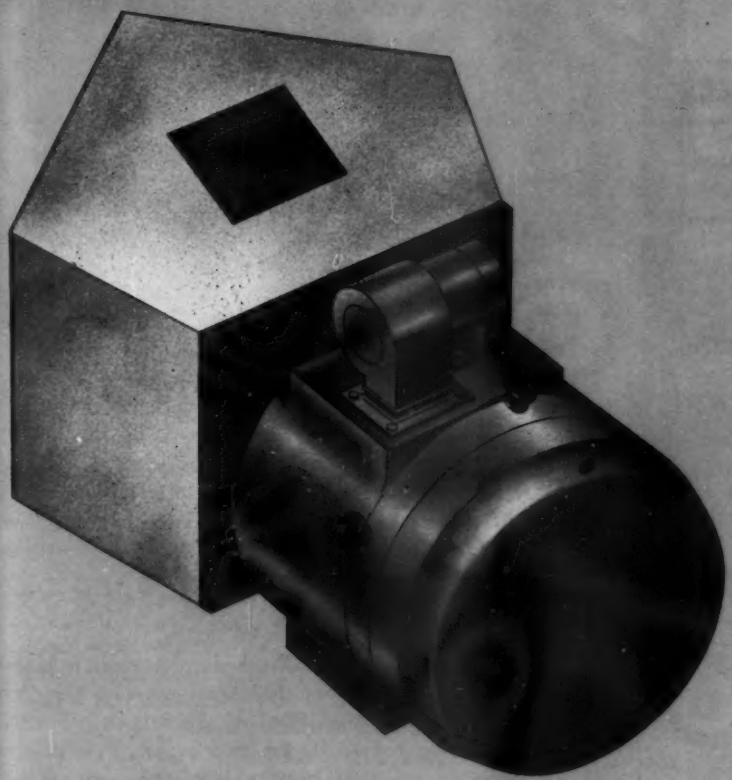

acoustic noise generator

This high intensity noise source will effectively simulate rocket or jet engine noise over a frequency of 20 to 5000 cps with intensities up to 165 db. Its output in the audio frequency range further broadens its application in the field of environmental testing. The generator is mounted on a concrete test chamber, the design of which has a marked influence on both the sound intensity achieved and the sound intensity-frequency relationship. Avco Research and Advanced Development Division is prepared to supply detailed design information and construct, if desired, test chambers to customer requirements. The generator is now undergoing product engineering at Avco-RAD.

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Rudkin of Arma Wins Prize for N. Y. Chapter

Award of plaque by the IEE to the local Chapter obtaining the most new members each quarter goes to the New York Chapter in the first round of the contest. Robert H. Rudkin is the Chapter's Membership Chairman. He is an engineer in the Environmental Test Section, Arma Div. American Bosch Arma Corp. The plaque is to be presented to the chapter president at the Annual Meeting of the IEE, April 17-18.

The list of new IEE members in this issue reveals the growth of the IEE in various parts of the country, and shows the leadership of the New York Chapter.

The General Manager Speaks . . .

Another year has passed, and we in the office, which is the combined Headquarters for the Environmental Equipment Institute and the Institute of Environmental Engineers, are getting ready for another Annual Convention and Equipment Conference. This year, for the first time, it will be in New York City.

Young and growing organizations have one great advantage: it is always easy to top previous records. One evidence of the dynamic growth in the field of environmental simulation and testing is the steady increase in size and quality of our annual meetings. Each year the attendance has been higher than the preceding year, and each year we have been able to say with sincerity that the program is the best ever.

But the meeting is only one evidence of progress. In many other ways the past year has been significant. For example, last year there were no officially chartered local chapters of the IEE. This year, five will have representatives sitting in on the National Executive Committee meetings. In addition, a strong local group is forming in the Los Angeles area and expects to have its application ready shortly. At least two other groups have taken the first steps toward organization.

In the area of publications, strides have been equally noteworthy. The **Environmental Quarterly,** under the skillful guidance of Ray Mattingley, is becoming recognized as the authoritative publication in this field. Important from the viewpoint of continuing stability is the fact that it is now operating in the black and is no longer a drain on the treasuries of its patron Institutes.

The long-promised **Handbook** is at last close to reality. The Handbook Committee has been meeting regularly, and has every intention of having the first chapter ready for distribution in time for the meeting.

The past year has been noteworthy, and all who played a part in the numerous activities have every right to be proud. The best part of it all is the thought that this sort of thing snowballs. The more we do, the more we can do. We could not have done in 1956-57 what we did in 1957-58 because we did not have the members and financial support. It is inspiring to think of the progress that will be possible for both Institutes in 1958-59 as a result of the groundwork laid this past year.

GEORGE D. WILKINSON
General Manager, IEE and EEI

NEW UNIVERSAL DROP-TEST MACHINES give Precise Control of Shock Pulses *and* Exact Repeatability

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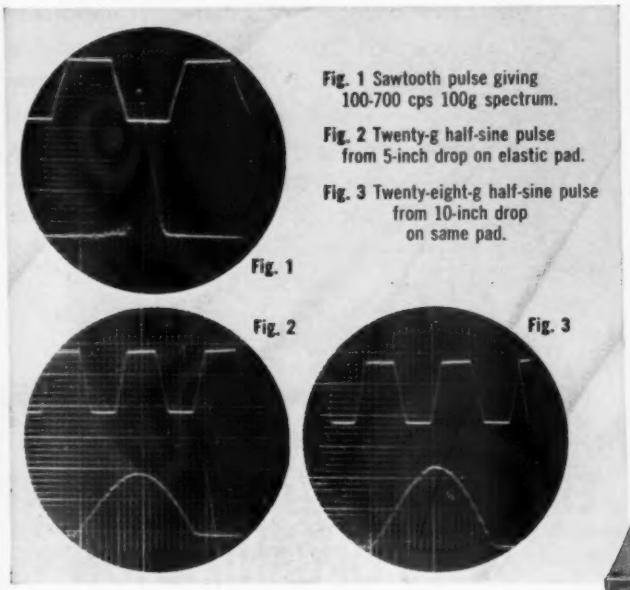


Fig. 1

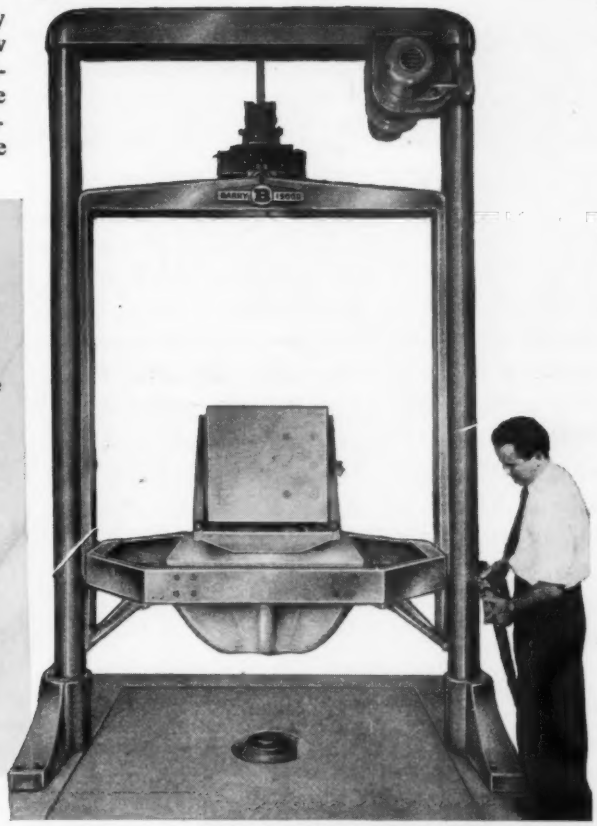
Fig. 2

Fig. 3

Fig. 1 Sawtooth pulse giving 100-700 cps 100g spectrum.

Fig. 2 Twenty-g half-sine pulse from 5-inch drop on elastic pad.

Fig. 3 Twenty-eight-g half-sine pulse from 10-inch drop on same pad.



Type 15000 Shock Machine

A nearly unlimited variety of pulses can be generated, including the saw tooth that produces the 100-700 cps 100g spectrum (Fig. 1) required in the Ramo-Wooldridge Missile Test Specification and the triangular and half-sine wave shapes of various MIL specifications. Complete control of the pulse is obtained by adjusting the drop distance (Figs. 2 and 3) and by placing the proper elastic or inelastic pulse-forming device on the anvil.

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The Search for Reliability

Editorial

We present in this issue articles by three men who are all probing for the right way to reliability in equipment and vehicles the Armed Services and other agencies of the Nation must depend upon. All three state or imply that we are not achieving the all-important reliability that we must have.

Mr. Ellsworth F. Seaman, of the Navy's Bureau of Ships, in his *Notes on Simulated Service Testing,* indicates that we are a long way from perfection in correlating the results of environmental tests of materials and components with the performance of finished equipment in its use environment. To avoid vast cost and confusion, he implies, we must solve this problem and soon. Mr. Seaman is a member of a new Dept. of Defense Committee on environmental standardization. He leads this group in a panel discussion of its work before the Second Annual Meeting of the IEE.

Mr. A. S. Richardson, of M. I. T.'s Dept. of Aeronautical Engineering (*Environmental Endurance Testing–Key to Reliability?*) states flatly that the specification qualification test does not ensure component reliability. He says: "The concept of component endurance relates directly to component performance in an environment, and thus provides a convenient and meaningful measure of component reliability." Mr. Richardson is Executive Officer of the Aeroelastic and Structures Research Laboratory.

An editorial in *Aviation Week,* Sept. 16, 1957, entitled *The "Missile Industry" Myth,* is in opposition to what the editorial alleges is an attempt by the Army to define a separate missile industry. Since we are not grinding either blade of that ax, it is not our purpose here to enter into that controversy. Suffice it to ask whether or not *Aviation Week* is resisting a new idea.

However . . . our third article is by Mr. Robert Lusser, Reliability Coordinator, Redstone Arsenal, in which he attempts to prove that "Production Environmental Testing" is not only a fallacy but is worse than worthless in the effort to attain reliability. We are pleased to be able to provide Mr. Lusser with a place to stand in order to say his piece.

Mr. Lusser also presents a paper, "Unreliability of Electronics—Cause and Cure," at the Second Annual Meeting of the IEE. Is it possible that Mr. Lusser has been a "voice crying in the wilderness"?

Under the enormously dangerous national circumstances of the Spring of 1958, we must listen to all the voices among us who might help us to do what we must to survive as a free people.

Let Mr. Lusser be heard.

—R.H.M.

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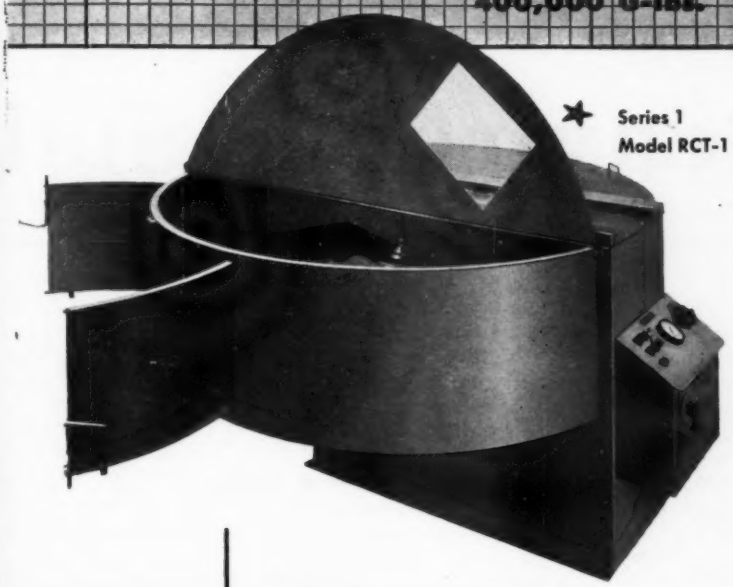

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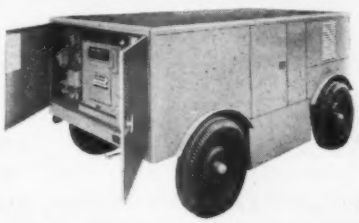

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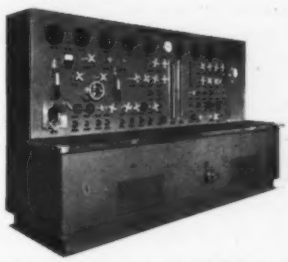

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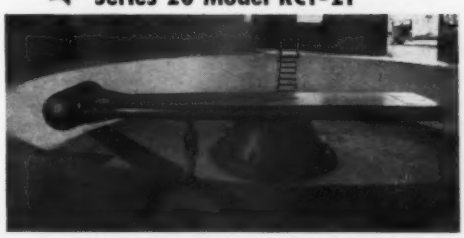

View of 22' radius arm and powerhead installed in test pit. This large Series 20 unit is designed for testing 4,000 lb. specimen at 100 G-rating.

Component endurance relates directly to component performance in an environment, the author states, and is a measure of reliability.

"The specification qualification test is not a sufficient safeguard to component reliability."

environmental

FOR ILLUSTRATIVE purposes, let us first consider the relay as a specific example. Nothing has been the object of maligning assaults for its unreliability more than the relay. And yet what is more reliable in our everyday lives? The relay completes your telephone call, turns your traffic light from red to green, makes the turning signal light in your car flash on and off, etc. Why, then, the vast difference in reliability between applications in telecommunication and in weapon systems? Answer: the *environment* is different.

Assume that we have a large number of relays, all from the same manufacturer, all conforming to specifications regarding design and operating conditions. From all appearances they are the same; but will they behave the same in the environment? Indeed not, as I shall attempt to show. But first we must design a test that simulates the anticipated environment.

Now a relay is a device that is intended to switch from one circuit to the next *on command*. The command signal is normally a current pulse which, when applied to the coils, activates a small arm and makes contact with one circuit, while breaking contact with another, as shown in Figure 1.

In the automatic control of a missile, the command pulses may come in a random order and, in the circuit shown, when a pulse is absent we want the circuit connection to be B-C, while when a pulse is present we want the circuit connection to be A-C. Any other combination of pulse-circuit connection constitutes faulty operation and the relay fails to perform its desired function. It is said to be unreliable when that happens.*

Now comes the crucial question. How do we simulate the environment? *For the given missile*, other considerations (too lengthy to detail here) will enable us to be fairly certain, most of the time, that the pulse repetition rate for the electrical environment lies, say, between zero and 30 pulses per second with a tendency to "bunch up" around the rate of 16 pulses per second. Similarly, the G loads may run between zero and ± 40 G's with a tendency to bunch-up at around ± 3 G's, as shown in Figure 2.

Making A Start

Once we have curves that simulate both the circuit and acceleration field environments, we can begin. But we come back to the No. One question: How? Well, we have to begin somewhere, so let's run some sinusoidal acceleration tests. We hook up our random pulse generator, and start the relay chattering away in accordance with the distribution curve for pulse repetition rate. We turn on the shaker and test, say at ±40 G's. We wait, and we probably don't have to wait very long to find that the relay has faulted. Let's record the time that elapsed while the relay operated satisfactorily. Repeating the test at the same G-load several times, we find that the time to failure, or relay life at that load level, varies in a statistical manner. Our test data may look something like Figure 3.

We may notice that the life of the relay at that load level has a tendency to bunch up around some average value, while relatively few relay lives appear at values far removed from the average value. We naturally have a suspicion that the tendency to bunch up will occur at different times if we test at other G levels. And so, testing at several G levels, we finally collect enough data so that something resembling Figure 4 may be plotted.

Now we are beginning to have a feeling for what the acceleration environment is doing to the relay's re-

*The engineer must decide in advance what constitutes faulty operation. In some cases, a single faulty connection may be tolerated: in others, the number of faulty connections per unit time is a better index of reliability.

A. S. RICHARDSON, JR.
Massachusetts Institute of Technology

endurance testing

Key to Reliability?

liability; namely, that the relay is more reliable at low G-loads than at high G-loads for a given life. However, at a given load level it is not possible to predict the life of a single relay. Figure 5 shows that relay life is statistically distributed.

The data can also be presented in another way which takes into account both effects indicated on Figures 4 and 5. Now look at Figure 6. The curves are labeled with the *cumulative probability* value. For example, point A is the point at which the relay will have a 10 percent chance of failure (90 percent of survival) at that G-load for that period of time.

The Specification Qualification Test

There appears to be a tendency on the part of people who write specifications "to try to buy" 100 percent reliability through the specification. The theory seems to be that one should specify a qualification test based upon estimated average values of time, and of environmental intensity, for example, G-load, temperature, humidity, voltage, etc. Often the average values are increased by some "factor of safety" and the specification then requires that there shall be no failures, or malfunction, under the specified conditions. The specification test requirements may have the general characteristics outlined by Figure 7. Accordingly, if a "representative number" of items are tested under these conditions, and if there are no failures, the item has passed, and is deemed to be qualified to operate satisfactorily under the particular environmental conditions.

Why does this approach fail to give the 100 percent reliability desired, or as it often happens, fail to give even 80 percent or 70 percent reliability under similar environmental conditions?

Let us try to find the answer by considering a specific example. Suppose we wish to buy relays for operation in severe acceleration environments. Our qualification test specification calls for no-fault operation for 15 minutes at ± 10 G's acceleration—a rather severe requirement. Let us require the manufacturer to submit at least 10 relays to this test, and allow no failures for any of the relays tested. Framing these specifications with respect to the endurance curves of Figure 6, let point A coincide with the above specification.

But how can this be? I have already indicated that point A is associated with a 10 percent failure rate, and we have seen that no relays will be accepted if there are any failures whatsoever in the qualification test. It is easily shown that there is a finite probability of passing this test when the relay failure rate is 10 percent under the test conditions. In fact, the probability is about 34 percent*. In other words, approximately one out of every three lots, consisting of 10 units each, that are submitted to this test will pass, even though the failure rate is 10 percent. Qualification tests are normally conducted only once by the manufacturer and then certified. The product is presented to the commercial market for sale. Under these conditions, it is easy to see how unreliable products get into military weapons systems procurement channels.

To continue the example, consider the unsuspecting designer. He is presented with a choice of relays

*There are many excellent texts that provide the mathematical basis for the calculation of these probabilities; for example, *Probability Theory and Its Applications*, by William Feller, John Wiley and Sons, 1950.

TABLE I

Classification of Test Results According to G Level and Endurance

(Relay test-frequency, 30 cps—two of five G loads tested at 5, 10, 20, 30, 40 G's—total number of tests, 500)

G LEVEL	TOTAL TESTS	ENDURANCE RANGE (MIN.)	NO. OF TEST POINTS	FIRST PROBABILITY	CUMULATIVE PROBABILITY	AVERAGE ENDURANCE (MIN.)
20	100	0-10	8	.08	.08	5×.08
		10-20	19	.19	.27	15×.19
		20-40	26	.26	.53	30×.23
		40-60	38	.38	.91	50×.38
		60-90	9	.09	1.00	75×.09
	Totals:		100	1.00		36.8
30	100	0-10	16	.16	.16	5×.16
		10-20	42	.42	.58	15×.42
		20-40	20	.20	.78	30×.20
		40-60	13	.13	.91	50×.13
		60-90	9	.09	1.00	75×.09
	Totals:		100	1.00		26.3

supplied by manufacturers A, B, and C. All have submitted relays to the qualification test, and all have successfully passed. Assume that the failure rates for manufacturers A, B, and C, under the test conditions, are, respectively, 5, 10, and 20 percent. The probabilities of passing the test are, respectively, 58, 34, and 11 percent. Evidently manufacturer C has been lucky.

Designer's Plight

As for the designer, all three manufacturers look equally good to him on the basis of the test. Certainly, we could not blame him for concluding that each relay is as reliable as the next. Under this assumption, he would perhaps make his selection on the basis of some other design consideration—weight, response characteristics, physical configuration, etc. Furthermore, he may require a substantial number of these relays in his circuit design. Let's say, for simplicity, that 10 relays are used in his design. If he chooses the relay manufactured by A, his reliability under the environmental conditions corresponding to the qualification test is 58 percent, for manufacturer B, 34 percent, and for manufacturer C, 11 percent.

The helpless designer probably gets it in the neck when these poor reliability figures manifest themselves in service. In fact, those who lack an understanding of this problem have asked: "How can a designer take a component that is 100 percent reliable and make such a poor showing of it in service?" The answer, of course,

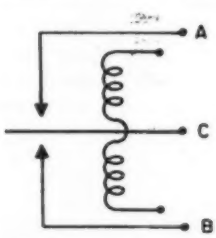

Figure 1. Relay circuit.

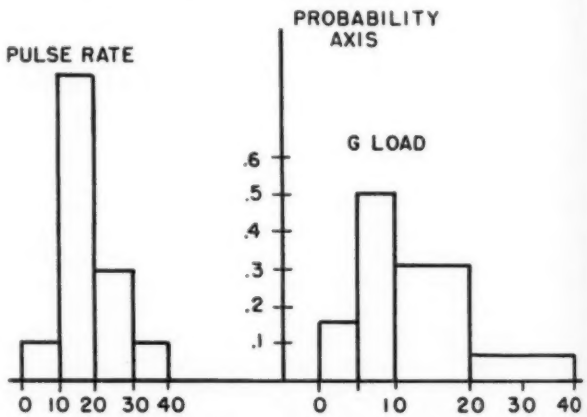

Figure 2. Relative occurrence of pulse repetition rate and g loads.

is that the component is *not* 100 *percent reliable to begin with.*

The Random Environment

Thus far, we have considered very simple environments—those that apply a steady constant amplitude sinusoidal acceleration field to the relay. Actual environments are much more complicated. They contain many acceleration amplitudes and many frequency components. However, let us adopt a certain hypothesis which can be tested. Assume that we can compute the probability of having no faults in a time interval $T = T_1 + T_2$ during which time the relay is subject to a G level $G = G_1$ for a time T_1 and $G = G_2$ for a time interval T_2. We further assume that we can use the results of our sinusoidal G tests to compute the required probabilities. Table I shows how we might go about setting up the calculation.

Note in Table I that the actual values of the endurance time for each test are not shown. Instead, I have grouped the times into boxes or cells and have

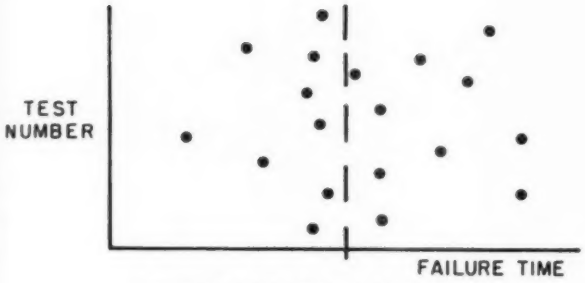

Figure 3. Life test at 40 g's.

listed the number of tests in which endurance times fall within a given cell. Hence, except for units attached to the size of the cells, we are dealing only with pure numbers. This is characteristic of probabilities—they *are* pure numbers. Secondly, note that we compute probabilities by dividing the number of test points in a given cell by the total number of tests at that G level. Thus the first probability number gives the fraction of a given (large) number of relays that will malfunction at exactly the endurance time somewhere within a particular cell.

The cumulative probability is that fraction of all tests in a single G load category which may be expected to yield relay-faults within a given time interval—always counted from time zero. Putting it another way, for a specified time interval, our chances of having a relay fail prior to the specified time is given by the cumulative probability. We have here a reliability measure—a chance of failure in a specified time.

Now the cumulative probability, or the probability of unsuccessful relay operations, at the load level of 20 G's for a period of 20 minutes, according to Table 1, is 27 percent. Therefore, the chance of successful relay operations under these conditions is 100 percent minus 27 percent or 73 percent. Similarly, the chance of success at the G load of 30 G's for 20 minutes is found to be 42 percent. According to the hypothesis, we may compute the chance of successful combined operations from the theorem of independent probabilities. Accordingly, the chance of successful relay operations under the specified combined conditions is 73 percent times 42 percent, or 30.6 percent for a total of 40 minutes.

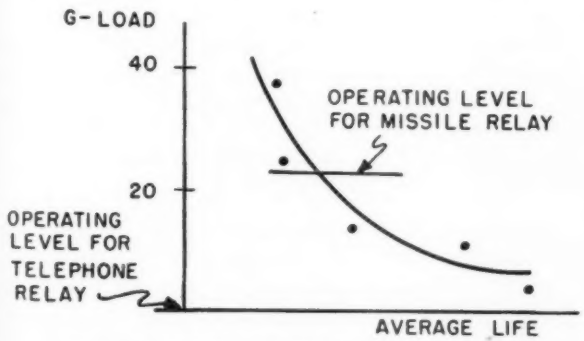

Figure 4. Relation of average life to g level.

MR. RICHARDSON holds two M.I.T. degrees in aeronautical engineering, the S.B. and the S.M. Besides being the Executive officer of the Aeroelastic and Structures Research Laboratory at M.I.T., he is founder and President of Research Consulting Associates, Lexington, Mass. Mr. Richardson is the author or co-author of 16 technical publications, papers, and reports.

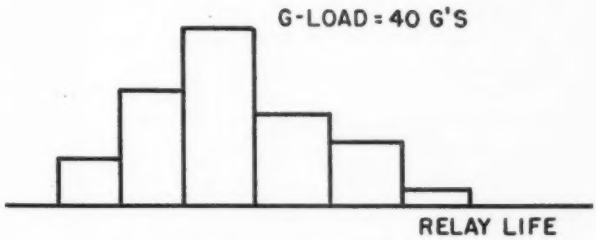

Figure 5. Statistical properties of life tests.

Let us pursue the hypothesis further, and this time consider not just two, but several, G-load levels. Furthermore, we devise a method of combining the G-load levels so that the relative time at each level is chosen in accordance with the probability level for G-load (Fig. 2). First, we choose a time interval, T. Next divide this time interval into as many time segments as there are G-levels. Then make the *relative lengths* of the time segments follow the G-load probability curve. Finally, compute the probability of successful relay operations for the specified time interval, as in the simple case of only two G-load levels. Let us repeat the entire calculation for several specified time intervals. The results could be reduced to a single curve having the appearance of Figure 8. How can we check the hypothesis? Quite simply. Suppose, for example, that the particular G-load represented in the calculations followed a Raleigh-type distribution. Therefore, the hypothesis may be checked by running some more tests.

One simple scheme for obtaining a Raleigh distribution in the laboratory involves applying a random noise signal to a high Q, or narrow-band, filter.* The output peak amplitude follows a Raleigh curve. This fact has been demonstrated both analytically and experimentally. The filter must be tuned to the same frequency used in the sinusoidal tests.

The endurance times** that are obtained from the random-shake tests will, of course, follow some sort of probability distribution. If the experimental distribution curve agrees with the theoretical curve, the hypothesis is proved. If there is little or no agreement then the hypothesis is not proved. If the hypothesis is not proved, and this is a definite possibility, the ex-

(Continued on Page 24)

*Actual environments are considerably more complex than the simple example treated here. Therefore, representation of the system as a single-degree-of-freedom, sharply tuned, singly resonant mode, will not, in general, be valid.

**Time to failure is synonymous

developments

Committee on Environmental Standardization

A new Dept. of Defense Committee charged with standardization of environmental testing specifications, terminology, and techniques made its public debut in a panel presentation before the IEE's Second Annual Meeting April 17-18 in New York City.

Gerard J. Marks, Office of the Asst. Secretary of Defense, is Chairman. Others on the Committee are: David Askin, Chief, Environmental Test Sect., Pittman-Dun Lab., Frankford Arsenal; Ellsworth F. Seaman, Bureau of Ships, Dept. of the Navy; Dr. William Brierly, Quartermaster Corps R. & D Center; and Wayne B. Yarcho, Environmental Criteria Branch, WADC.

Two of these men—Askin and Seaman—are also members of the Committee for the Handbook of the Environment, which is engaged in the monumental task of producing, under the joint sponsorship of the IEE and the EEI, a multi-volume *Handbook of the Environment*, as a continuing series of about 30 publications. The Air Force is also represented on the Handbook Committee by Robert L. Hankey, WADC. According to Ray H. Mattingley, Editor-in-chief of the *Handbook*, the Handbook Committee will evaluate its work in relation to the D.O.D. Committee through Askin and Seaman.

Los Angeles IEE Chapter Forming

According to Irving Polak, Vice-President of the IEE from its beginning until April 1st of this year, a vigorous movement has been started in the Los Angeles area toward formation of a local chapter of the IEE on the West Coast. At present, no chapter exists farther west than Chicago. An attempt is being made continuously, Polak said, to work in harmony with the regional group in California known as the Society of Environmental Engineers. Dr. George D. Wilkinson, General Manager of the IEE, states that a standing invitation exists for the S.E.E. to join forces with the IEE.

•

Lewis S. Goodfriend is the Editor of a relatively new magazine, *Noise Control*, published bi-monthly by the American Institute of Physics for the Acoustical Society of America. Advertising is handled by T. Vorburger, Adv. Mgr., Institute of Physics.

•

Kate Long Hill, Eatontown, N. J., has been appointed Staff Artist for the *Environmental Quarterly*. The diagram accompanying the article by E. F. Seaman is an example of her work.

Regional Meetings for IEE?

Dr. George D. Wilkinson, General Manager, IEE, has announced that regional meetings of the IEE may become a reality. These would be patterned after the massive annual meeting of the Institute, but on a much smaller scale, he said, and would be especially important to the California area, since West Coast engineers do not benefit fully from Mid-west and East Coast meetings.

•

A new Environmental Criteria List has been published by the Environmental Criteria Branch and the Laboratories of the Wright Air Development Center. The list supersedes the one dated Nov. 1956. Write Commander, WADC, ATTN: WCLOD-2, Wright-Patterson AF Base, Ohio.

Electronics Magazine Reports on Environmental Testing

A 16-page report on environmental testing appears in the March 28 issue of *Electronics*. The author is Michael F. Tomaino, Associate Editor of this McGraw-Hill publication. This is the first major treatment of the new technology by the technical press.

•

The French Air Ministry has received four giant environmental test chambers for use in the Ministry's testing lab at Palaiseau, outside Paris. Origin: Tenney Engineering, Inc., Union N. J., U. S. A. The chambers, weighing a total of 31 tons, include a walk-in combination alt-temp-humidity chamber; a small-component alt-temp-humidity chamber; a sand and dust chamber, and an explosion chamber.

•

The Scientific Apparatus Makers Association reports that only one out of seven top managers in a survey of 500 of the country's largest manufacturers find R & D lab reports generally adequate. SAMA calls the R & D report "America's springboard to world supremacy." This poses a challenge to both the engineer and the new professional—the technical-scientific writer.

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Cincinnati Sub-Zero Products has just developed a 5 cubic-foot mechanical low-temperature metal curing unit with remote power pack for the Sperry Gyroscope Co. Used for temperature-cycling of critical inertial guidance components for missile and aircraft systems.

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Sensitivity	0.036 v at 600 ohms	0.04 v at 600 ohms	0.1 v at 600 ohms	0.16 v rms at 600 ohms for 10,000 w output	0.1 v at 600 ohms	0.05 v at 600 ohms	0.5 v at 600 ohms
Distortion	1% at 250 w, 1000 cps	0.75% at 500 w, 1000 cps	Less than 0.75% at 1 kw, 1000 cps	Less than 3% at 10 kw, 1000 cps	Less than 0.75% at 1 kw, 1000 cps	Less than 5% at 1 kw, 10 to 1000 cps	

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The belief, says Mr. Lusser, that mechanical and electrical devices fresh off the assembly line have a pronounced "infant mortality," followed by a long stretch of reliable life, is a fallacy. His recommendation: Replace PET with comprehensive test-to-failure programs.

Production Environmental Testing

ROBERT LUSSER, Redstone Arsenal

MUCH CREDIT is given to the concept of Production Environmental Testing, often referred to as PET. This situation is based on the belief that components and assemblies, as they come from the production line, may be made more reliable by bumping, shaking, or burning-in.

Human Mortality Analogy

It is widely believed that, in analogy to human vital statistics, mechanical and electronic devices also *must* have a pronounced "infant mortality," which is then followed by a "long stretch of consistently low-chance failures," as shown in Figure 1. It is not until the end of this long, low stretch that the failure rate is believed to rise again because of growing incidence of wear-out failures.

This analogy to human statistics is a fallacy.

The high peak of human infant mortality is caused by a variety of incidents, such as birth trauma, changes of biological conditions, rapid growth, nutritional hazards, and infectious diseases. Later, as these hazards become less severe and less frequent, the annual death rate decreases to approximately one-tenth of the initial rate, as shown in Figure 2.

In mechanical and electronic equipment, nothing of that sort happens. "Birth" consists of a mere switching-on, lacking any violence and trauma. Nothing "grows." No basic changes occur that cannot be determined during the prototype phase. Infectious diseases do not exist. And, in contrast to human beings, components can be,

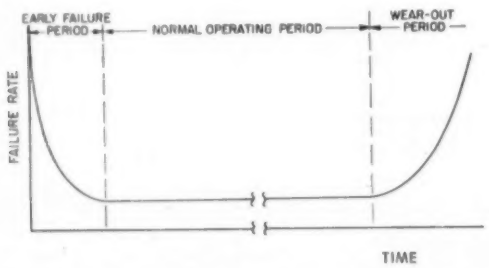

Figure 1. Model of force of mortality distribution underlying PET concept.

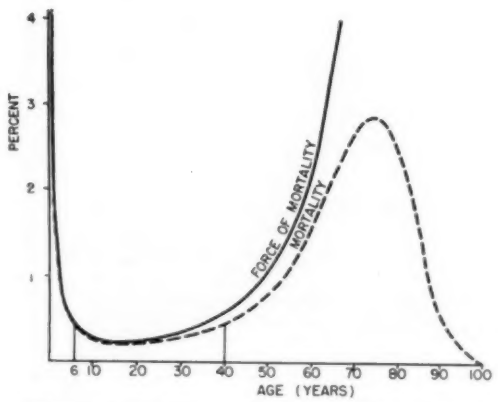

Figure 2. Human force of mortality curve.

and actually are, inspected and checked out *prior to "birth."*

Little wonder that large-scale test programs for electronic components and assemblies show no infant mortality. Its duration has never been disclosed, and one is left in the dark as to whether the alleged infant mortality is a matter of minutes, days, or months.

Naturally, when complex equipment is checked out and tested at the end of the production line, it may show inadequacies. There may be wiring errors, damaged parts, improperly centered characteristics. However, such incidents must not be confused with infant mortality since they clearly belong in the production and inspection phase *preceding "birth,"* rather than in the actual life.

Obviously, if an equipment is unreliable in its first hour of life, it will be unreliable in its hundredth and thousandth hour as well. Yet, it is widely believed that equipment will become reliable just by "living," without any effort in redesigning, retesting, and remanufacturing. This is the foundation of the PET concept.

Another outgrowth of the human mortality analogy is the long "normal" operating period of equipment life (Fig. 1). As shown in Figure 2, the human mortality curve indeed has a long, low, and rather constant

stretch of mortality between the ages of six and forty years. This is caused by the amazing power of self-healing and regeneration of the living organisms. Mechanical and electronic equipment obviously does not have this capability at all. Therefore the long stretch of consistently low mortality doesn't exist either.

Why, then, is the idea of the "long, low stretch" widely accepted? The reason is not difficult to find. If the chosen time scale is one of a hundred hours, as usual, the failure rate may indeed appear constant. But if the time scale is one of years, as it should be for long-lived equipment, the distribution curve rises inexorably and progressively after "birth." This is illustrated in Figure 3.

It thus becomes obvious that Production Environmental Testing will not increase reliability. It may even decrease it. If sensitive devices are tested severely and/or for a long time, they may easily yield to fatigue or wear-out and fail prematurely in service; as a result, reliability will decrease, rather than increase.

Mortality vs. Force of Mortality

Although at present there is a growing awareness of the uselessness of PET, it is kept alive by several misinterpretations of failure statistics. For example, if failure rates are expressed in percent of the whole population, as is common practice, the result is a *mortality* histogram. If the population is small, a few dozen rather than hundreds or thousands, the mortality histogram will display a pronounced initial peak, as illustrated in Figure 4.

This initial peak, however, is not an indication of infant mortality. *Only if the related force of mortality displays an initial peak has one a case of infant mortality.* In Figure 4 the force of mortality (horizontal line) shows no initial peak, hence there is no infant mortality. (Force of mortality, in human vital statistics, can be defined loosely as the probability of death during the subsequent year. The reader wishing to know more about the difference between mortality and force of mortality may study "Mathematical Foundation of Reliability," by Dr. Erich Pieruschka, Redstone Arsenal, November, 1957.)

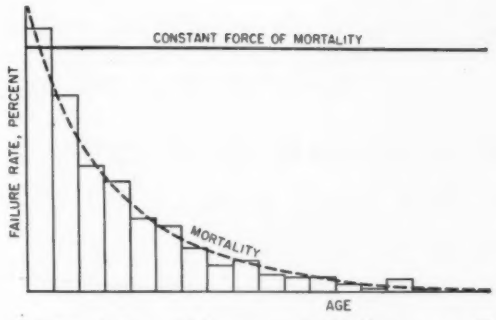

Figure 4. Mortality histogram indicating no "infant mortality."

"Brute Force" Shaking

There is another grave misconception: Production vibration tests are often begun with a greatly exaggerated amplitude, which is then reduced step by step until the equipment is no longer vibrated at all, but just "burned in." In this event, both mortality *and* force of mortality will show a high initial peak, as illustrated in Figure 5.

A high initial peak of the force of mortality curve, if produced by a high initial severity of test conditions, cannot be interpreted as true infant mortality. Exaggerated conditions do not simulate actual life. They are not natural and unavoidable, as with human beings, but are imposed arbitrarily. Initial peaks like that must therefore not be offered as proof that bugs may be shaken out by PET. As a matter of fact, bugs may be shaken in and reliability may badly decrease.

The idea of shaking the bugs out by brute force has much in common with the medieval superstition that mental patients can be cured by "beating the devil out." Needless to say, this is a gruesome mistake, in electronic equipment as well as in human beings. There is also a parallel between the shake-the-bugs-out concept and the old-fashioned medical belief that all patients, whether they suffer from athlet's foot or ulcers, may be cured by a

(*Continued on Page 33*)

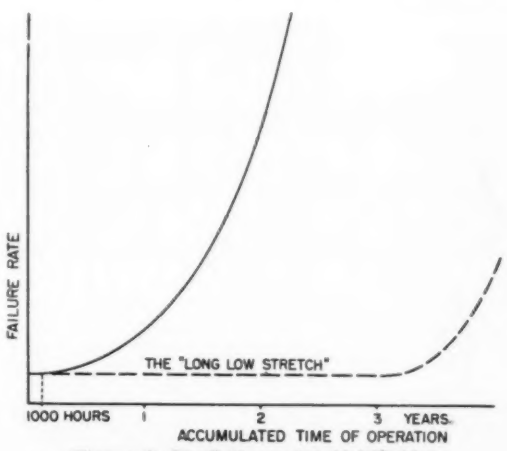

Figure 3. Realistic model distribution.

MR. LUSSER, Reliability Coordinator at Redstone Arsenal, studied electronics at the Univ. of Stuttgart after WW I. After receiving his Master's degree, he changed his field of interest from electronics to aeronautics. As head of the Prelim. Design Dept. at Messerschmitt Aircraft Co., he was responsible for the first design of the German standard fighter, the Me-109. In 1939, as Dir. of Aircraft Development at Heinkel Aircraft Co., he created the first jet fighter, the He-280. From 1942 until the end of the war, he was in charge of the German V-1, as Dir. of the Fieseler Aircraft Co. In 1948, Mr. Lusser came to the Naval Air Missile Test Center, Point Mugu, Calif., specializing in guided missile reliability, where he wrote several reports on that subject that have become classics. In April of 1953, he became Chief of the Army Ordnance Guided Missile Reliability Group, and later, Reliability Coordinator at Redstone Arsenal.

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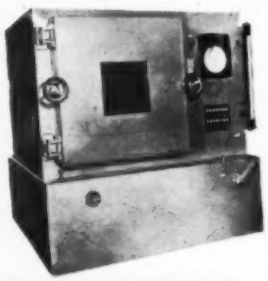

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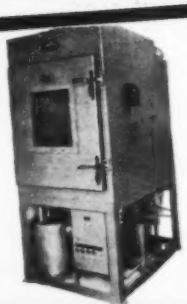

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ROBERT L. STALLARD, Vice-Pres., Publications. *Staff Engineer, The Martin Company (Denver), BS, Mechanical Engineering, Stevens Inst. of Technology, 1944. Now involved in Titan missile vibration tests.*

IEE Liberalizes Company Membership Privileges

By ballot cast in March the membership of the IEE approved an amendment to the by-laws of the society to the end that a Company Member may, if it wishes, designate up to three of its employees to enjoy the same status as regular Members in the IEE. This means, in effect, that such persons would be able to vote and hold office. In the past, the Company Member was entitled only to designate up to five representatives who were not entitled to vote or hold office and were subject to change at any time. Under the new by-law, the Company Member may still designate up to five representatives, but instead of receiving only three copies of the "Proceedings" and the *Environmental Quarterly*, the Company will receive five.

Another amendment makes the junior past president an *ex officio* member of the Executive Committee.

PROCEEDINGS TO CARRY ADVERTISING

The *Proceedings* of the Second Annual Meeting of the IEE will carry advertisements. It is expected that this publication will appear in a limited edition of around 1,000. For details on space rates, availability, and general requirements, write to Proceedings Editor, IEE, 9 Spring St., Princeton, N. J.

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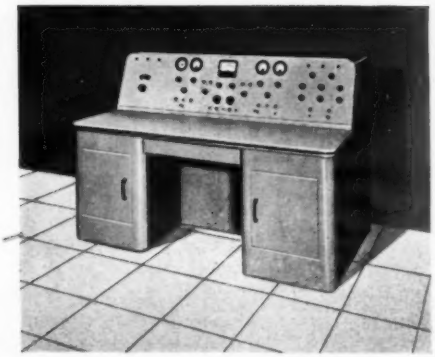

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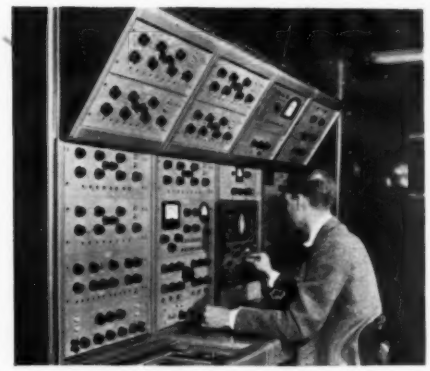

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MB has built over 850 electronic amplifiers for vibration test systems since 1945. More than 275 are 3 KW and larger. In advancing the science of complex motion testing, MB builds the required electronic gear with similar advanced thinking . . . to make it easier to use, and fit for future needs.

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The largest field service organization of vibration specialists are on call nationwide to users of MB test systems. They provide technically qualified service on the *whole system.*

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T666	C25H	3500 peak	2500 rms
T888	C25HB	5000 peak	3500 rms

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Notes On
Simulated Service Testing

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Definitions

Simulated service testing has developed because of the Armed Services' need to know in advance whether or not a product will function properly and reliably when placed in service.

Simulated service testing may be defined as testing conducted under controlled laboratory conditions under which an attempt is made to apply all *significant* factors met in actual service. Every factor that affects the level of performance of the test item in any vital way is significant. When these tests are conducted with no attempt to reduce time or increase severity in comparison with the service expectation, they are considered *first order simulation.*

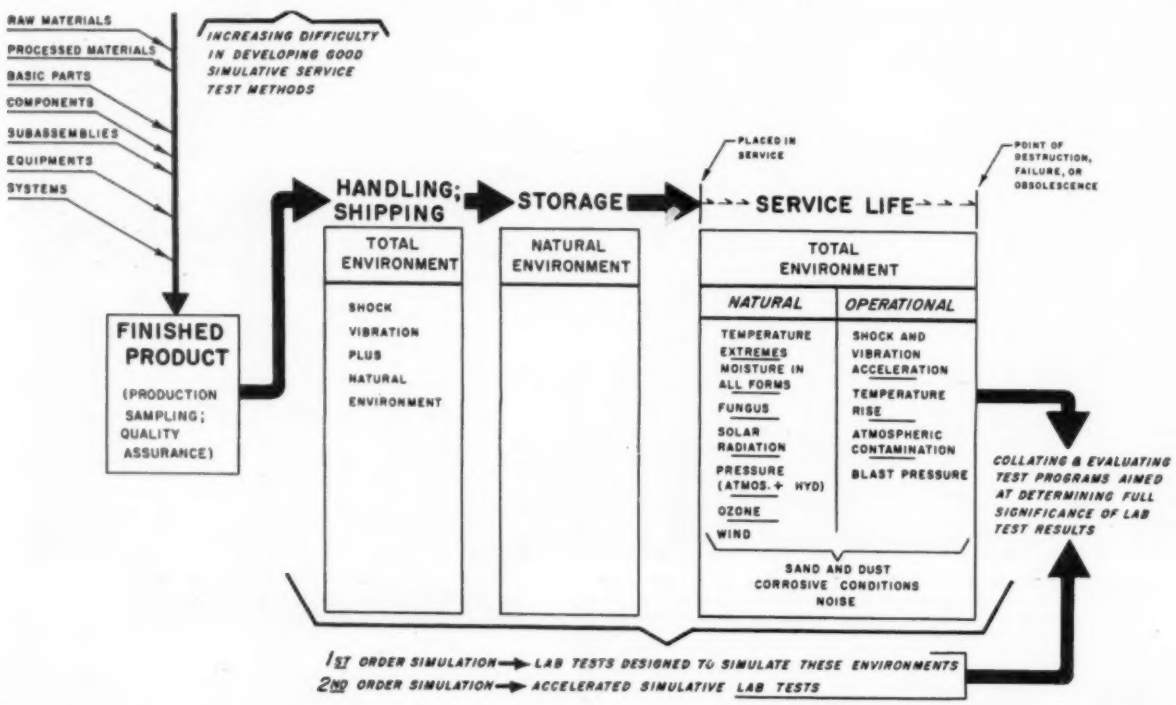
Tests conducted with testing time reduced and with severity increased but intended to approach the same test conclusions as in first order simulation are referred to as *second order simulation,* and sometimes simply as *accelerated testing.*

Environment may be defined as the performance-affecting conditions that surround material. Environment is subdivided into *natural environment,* such as climatic characteristics, and *operational environment,* which is created by operation of material. When the operational environment is super-imposed upon the natural environment, the synthesis is referred to as the *total environment.*

Sometimes the same sample or identical samples are circulated among a preselected group of laboratories to obtain information leading to more reproducible test methods and greater uniformity in lab testing procedures. This process is known as *round-robin* testing.

Testing Basic Materials

Simulated service testing is desirable for basic materials and parts, especially for a material or component that will later have a great variety of applications. The principal problem is how to bridge the gap in significance of test results between basic materials and end products. *A partial answer may be the design of material-test samples with geometric relationships that generally represent usage in end products.*



Valid simulation either in test methods or test samples is difficult to achieve in all cases. In many instances a reasonably close approach to solution of the test problem may be all that can be expected at the present state of the art.

The problems that exist include:

(a) Climatic conditions found in natural environments occur in such a variety of sequences and combinations that no single standard definition of characteristics can be fully accurate.

(b) What degree of importance should be assigned to simulation of environmental extremes of severity? The answer to this determines cost and availability of both the test facilities and the end items.

(c) How can the requirements for scaled-down accelerated simulated service tests be more accurately and quickly developed?

These abstract problem statements are translated into practical terms in the following three examples:

Example A

This example points up the effort that is needed to develop reproducible tests.

A standardization program was planned, using statistical design of experiment, to establish greater uniformity criteria in a certain type of humidity chamber. Chambers were tested in terms of performance of oil-base rust preventives on steel panels. Eighteen laboratories participated. Three oils were used, and three runs were made for each oil, using two test methods. Tests covered a period of seven months. The difference between method averages was obscured by the large dispersion among lab averages. And within the same lab the variability was considerable. The conclusion drawn was that procedures used in different labs should be carefully analyzed for variations significant to end results. It was also concluded that variability inherent in the chambers could have been the reason for the disparity.

Example B

A test method for electrical insulating varnish requires that brass rods be dipped in the varnish, dried, and then tested for dielectric breakdown after immersion in salt water. Variations in results leave much to be desired in the test method. This raises a number of questions: Do variations in results reflect heterogeneity in the varnish? Is the test on a thin coating on a smooth rod too severe as compared to the impregnation usage of the varnish? Does the introduction of some kind of contamination during test sample preparation influence the results?

Example C

Dumb-bell test specimens are used to determine the tensile strength of a certain type of molded plastic. To what degree does the performance of the dumb-bell sample simulate the performance of an end product having a complex configuration? Does the final product design cause stress concentration in a sharp angle leading to early failure? Could tests on a basic material sample have forecast this failure?

First Step

A necessary first step in the development of simulated test

(*Continued on Page 28*)

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IEE LOCAL CHAPTER NEWS

Proposed Los Angeles Chapter Is Under Way

LOS ANGELES—Under the dynamic leadership of Irving P. Polak, a Vice President of the IEE from its inception to March 31 of this year, a local chapter is being rapidly formed in Southern California, with headquarters in Los Angeles. In the initial effort to launch this chapter, Polak was assisted by Bruno J. Forsher.

Forty-five men came together on March 12 at an organization meeting chaired by Polak, and out of this meeting came the decision to name the new group the "Los Angeles Chapter," and the approval of a steering committee:

General Chairman—Polak, Marquardt Aircraft Co.
Program and Publicity—Forsher, Hughes Aircraft Co.
Membership—Frank Schwark, Rocketdyne
By-laws—Robert Law-Rie, Hughes Aircraft Co.
Rep. to National Exec. Cmtee:—Jack Mason, Marquardt Aircraft Co.
Ambassadors to SEE—Stuart Giles, BEMCO; Dave Douglas, Rocketdyne.

The nominating committee had included: Mason, John Windle of Wyle Lab. and George Traut of Hughes. The group discussed the mushrooming status of the Institute of Environmental Engineers in comparison with the geographically limited Society of Environmental Engineers, and agreed that the Los Angeles Chapter would never in any way obstruct the SEE group. On the contrary, it took action to insure good diplomatic relations through the appointment of Giles and Douglas. Continued approach will be made to the SEE with regard to merging its power and influence with the larger national society.

Forsher arranged a program for an April 9 meeting as follows: Wilson Bradley, General Mgr, Endevco Corp., speaking and showing a film on "Vibration and Its Measurement."

Mid-Atlantic Is Fourth Chapter

PHILADELPHIA—The Mid-Atlantic Chapter is now a legal entity after approval of its application by the IEE Executive Committee. Its officers are:

Chariman—David Askin, Frankford Arsenal
Vice Chairman—Henry L. Stein, American Electronics Labs, Inc.
National Director—Peter Zukauskas, The Martin Co.
Secretary—Martin S. Schletter, Tenney Engineering, Inc.
Treasurer—Stuart G. Hibben, Westinghouse Air Arm Div.
Chapter Directors—H. C. Jones, Westinghouse Air Arm Div.; Frederick M. Reitz, Emerson Research Lab.; Theodore F. Foti, The Martin Co.; and Peter J. Zukauskas, The Martin Co.

At its February meeting at Frankford Arsenal, the Chapter and its guests (87 persons) toured Frankford Arsenal Environmental Test Lab and listened to E. F. Dertinger speak on "The Role of Environmental Testing in Guided Missile Programs." Dertinger is Head, Reliability and Wt. Control Sect, Missile Guidance Dept., Arma Div., Am. Bosch Arma Corp. Dertinger emphasized the point that the reliability of missiles can be considerably increased by the proper use of rigorous environmental testing in the laboratory. Special guests included Cecil C. Fawcett, Director of Pitman-Dunn Labs; Col. George T. Petersen representing the Commanding General of Frankford Arsenal; and Lt. Col. Stanley W. Tyler, Executive Officer.

(Continued on Page 30)

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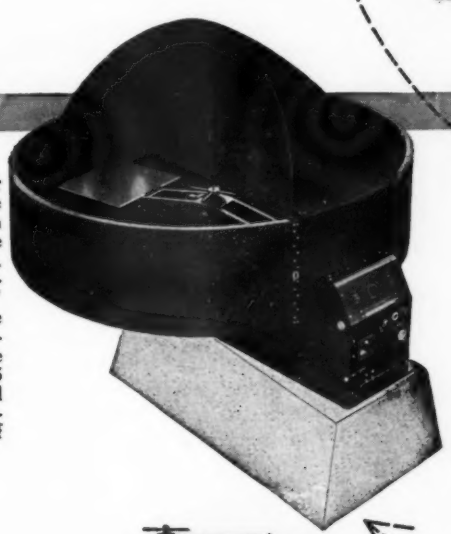
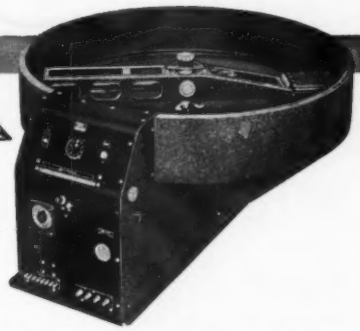
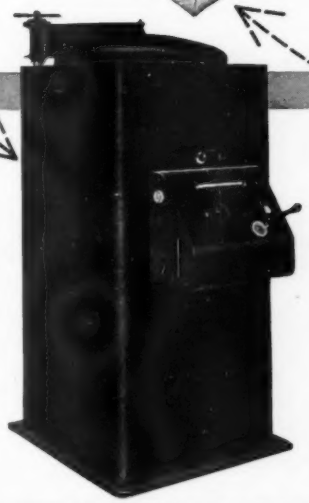


MODEL C159 The larger capacity of this machine permits whole system components and complete packages to be tested. Two objects, each weighing 100 pounds and 24" x 24" x 18" in size, can be accommodated simultaneously. G-range of the machine is 0.024 G to 75 G's. Maximum centrifugal capacity is 2000 G-pounds. Nominal radius of gyration 48".



MODEL B78 Used primarily for testing relays, switches, tubes, motors, valves, and other small components, and to calibrate and evaluate accelerometers. Accommodates objects weighing up to 25 lbs.; has G-range of 0.017 G to 120 G's. Maximum centrifugal capacity is 1200 G-pounds. Nominal radius of gyration 24".



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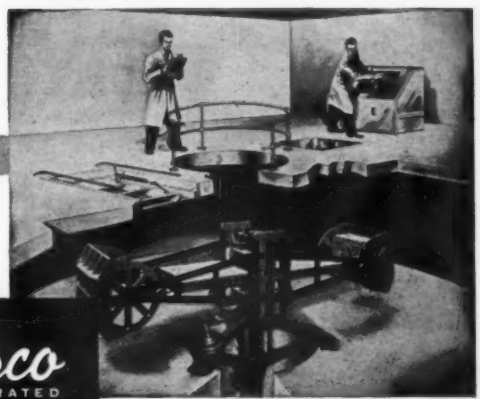

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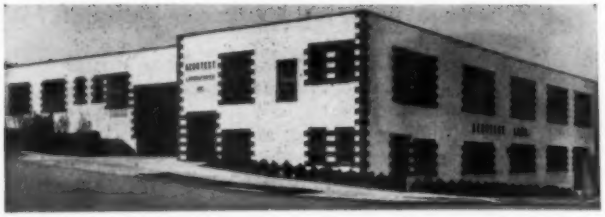

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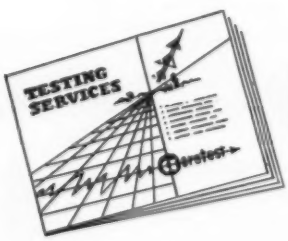

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ENDURANCE TESTING

(Continued from page 11)

planation for the discrepancy may be difficult to find.

Value of Many Tests

By conducting a great many tests, the environmental test engineer may be certain of at least one thing: the discrepancy is not due to sample variations commonly found in small sample sizes. Probably some physical process is at the root of the difficulty. At any rate, the wary test engineer realizes that the hypothesis is voided by the experimental results, and he has no alternative but to rule out sinusoidal testing as a useful means of simulating the environment. Suppose the hypothesis is proved? In that case, one can obtain endurance curves for random loading conditions, from data collected under sinusoidal loading conditions. This can effect considerable savings in time and money.

For example, assume that the relay is to be applied in several environments. Assume also, for simplicity, that changes in the environment have no effect on the probability distribution for pulse repetition rate; that is, the circuit environment is assumed to remain constant in that regard. However, suppose that both the distribution of G-load and the mean-squared G-load are affected. Perhaps there are five distribution conditions and five mean-squared G-load conditions—a total "product-space" of 25 points. We have proved our previous hypothesis by testing, say, with one of the environmental conditions. Hence, we have a confident feeling that we can apply the method to the other 24 environ-

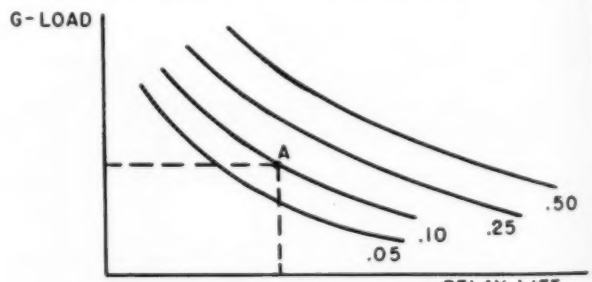

Figure 6. Endurance curves for relay test.

mental conditions, thus obtaining 25 endurance curves without conducting any more tests. In Table II, I show a comparison for the sake of economics. It is evident, at once, that either method of testing will be costly. However, in this case it is also evident that sinusoidal testing, *coupled with a judicious amount of random testing,* is more economical than random testing alone.

Reducing Enormous Costs

Now, you may ask: "Is there any way that we can further reduce the enormous costs apparently involved in environmental testing?"

There is. The application of sampling plans based upon experimentally established failure patterns can reduce testing costs considerably. Fitting the most economical environmental test procedure to failure pat-

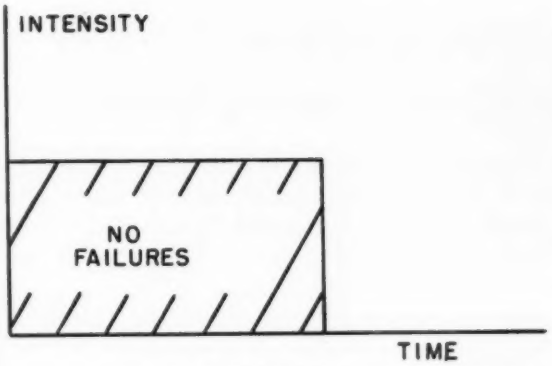

Figure 7. Qualification test specification.

terns of different types is quite a problem by itself and certainly deserves attention. The methods by which we may compute or otherwise determine the true environmental probability distribution is another area deserving constant attention. Other effects, such as the effect of frequency on the endurance curves, are likely to be very important and deserving of attention.

The whole area of specification writing to an ac-

(Continued on Page 26)

TABLE II

Comparison of Total Number of Tests Required for 25 Environmental Conditions.

I. Sinusoidal Shake-Test Method

No. of G-load conditions	5	
No. of tests at each G-load	100	
Total No. of sinusoidal tests		500
No. of random shake check conditions	1	
No. of tests at each check condition	100	
Total No. of random shake tests		100
Grand Total of All Tests		600

II. Random Shake-Test Method

No. of random-shake conditions	25	
No. of tests at each condition	100	
Grand Total of All Tests		2500

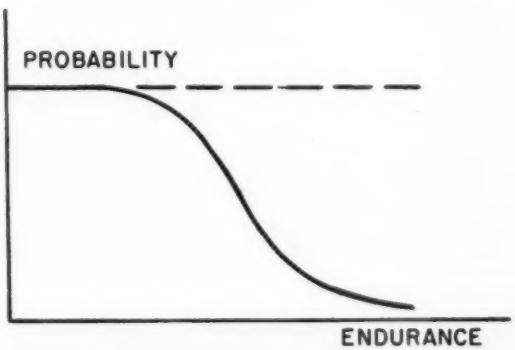

Figure 8. Chance of successful operations under combined g-load levels for specific endurance (times).

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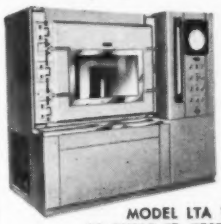

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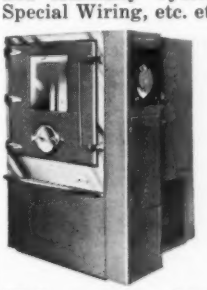

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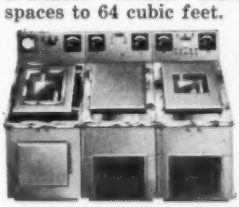

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(Continued from Proceeding Page)
ceptable endurance limit, and reliability (or probability) limit, is *critical*, and work that is now in progress should be accelerated—otherwise confusion will continue to exist in this area. Large economic questions, such as how subcontractors can be helped to understand reliability better than they do now, and how they can be induced to accept more responsibility for satisfactory service life of their products; how designers can better appreciate the importance of endurance, and how they can design endurance into a product, are all questions demanding immediate answers.

Conclusions

The concept of component endurance relates directly to component performance in an environment, and thus provides a convenient and meaningful measure of component reliability.

The specification qualification test is not a sufficient safeguard to component reliability. The endurance test affords the designer more information of the sort needed to design equipment with reliability in mind.

The sinusoidal test may apply to environments with random time varying intensity levels provided the effect of frequency, if any, is known or determinable.

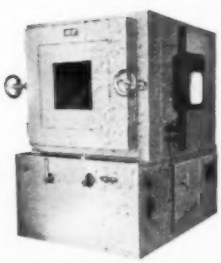
When the sinusoidal test data can be used to generate failure probabilities under random intensity levels, it may be possible to effect a significant saving in cost of the reliability program by substantially reducing the number of required tests.

EEI Plans Uniform Cost and Reporting System

Manufacturing members of the Environmental Equipment Institute have voted in favor of a program to perfect an expense reporting system similar to that in use by most other trade associations, according to Dr. George D. Wilkinson, General Manager of the EEI and President of George D. Wilkinson Associates, Consultants in Management. In outline, this system would consist of a uniform report to be prepared annually by each member and submitted to the General Manager, he said.

The detailed figures would be assimilated, disguised, and published in summary form for the benefit of participating companies. Dr. Wilkinson states about this program: "Summary reports of this nature are extremely valuable to management. They enable progressive companies to compare their operations with others in the same industry. We expect that the report will show the average, the high, and the low figures. The expense figures will be broken down into general categories, so that the participating companies can see where they had deviated from the industry norm."

ANY SIZE
TEST EQUIPMENT



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Handbook Project Develops Thrust

IEE Members to Receive First Volume Mid-summer

The fair-haired joint project of the Institute of Environmental Engineers and the Environmental Equipment Institute—*The Handbook of the Environment*—was given its formal launching to the public at the Second Annual Meeting of the IEE April 17-18 in New York City.

Everyone who attended the meeting received a copy of the first output of the Committee for the Handbook of the Environment, which included the Introduction, Table of Contents, a listing of the Committee and its Sub-committees organized to date, and a general explanation of how and when the various volumes of the *Handbook* are to be published. The Introduction was written by John Cammarata, Assistant Chief Engineer, Arma Div., American Bosch Arma Corp, in collaboration with others of the Committee.

The basic Committee, having editorial and administrative control of the project, is composed of representatives of the IEE and the EEI. Ray H. Mattingley, Editor of the *Environmental Quarterly*, functions both as Executive Secretary of the Committee and as Editor-in-chief of the *Handbook*. The IEE-EEI representatives are: Cammarata; David Askin, Chief, Environmental Branch, Pittman-Dun Lab., Frankford Arsenal; Bernard Friedman, Technical Director, Tenney Engineering, Inc.; Ellsworth F. Seaman, Head, Standardization and Conservation Planning, Bureau of Ships, Dept. of the Navy; Dr. Alan E. Surosky, Melpar, Inc.; and Robert L. Hankey, Environmental Criteria Branch, Wright Air Development Center. These men are listed on the title page of the *Handbook* as the Board of Technical Editors.

According to the announcement released April 17 at the IEE Annual Meeting, the *Handbook* will be published as a continuing series of individual volumes on the various aspects of environmental simulation and testing. The first of these is forecast for distribution to the members of the IEE by mid-summer of this year. Because all of the sub-committee Editor-Chairmen are racing against time to produce first edition material on a crash basis, no prediction can be made as to which volume will be published first, according to Mattingley.

Dr. George D. Wilkinson, Gen. Mgr. of IEE and EEI, has stated that The *Handbook* is to be a continuous service to all members of the IEE and will be provided to

(*Continued on Page* 29)

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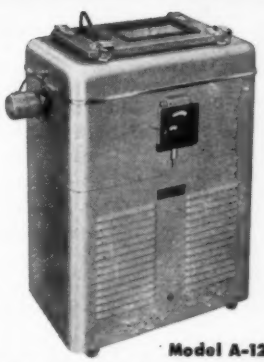
Model ASU-120-6-HC Altitude Test Unit

New 6 cu. ft. model for program testing with a temperature range of plus 300 to minus 100°F and a thermal capacity of 1200 BTU/hr. at −100°F. Equipped with temperature and altitude recording controllers. Altitude range at sea level to 90,000 feet. Chamber adapted to vacuum testing, and equipped wiih Fin Coil & Blower plus 2000-watt heater for mechanical air convection and optimum heat transfer.



Model A-120-2

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SIMULATED SERVICE TESTING

(*Continued from Page* 21)

methods is the analysis of field data originating in service or total environments. This is a combination of the conditions found in nature and the superimposed severities created by the operation of the system.

It is seldom the case that a single environmental condition may be used to evaluate material performance. The environmental conditions must be selected for the simulated test method so that they represent the most practical duplication of actual conditions. For example humidity-temperature combinations and their cycling always pose a difficult problem in test method design.

As another example, the stressing of the steel structural members of a ship at sea due to the natural elements may be increased in severity by the fatigue type of stressing associated with the constant vibration of machinery in operation.

The great number of factors and variables to be considered in evaluating the results of simulated test methods requires the use of something more than elementary inspection in order to discover true significance. *Statistical design of experiment* can be a most useful tool in planning a test program. Conclusions reached through this approach cannot be derived quickly by any other method in so complex a problem.

The older concept of testing by holding all factors but one constant while varying the remaining factor to a determining significance is very expensive compared with the statistical design of experiment. Furthermore, the old method does not permit evaluation of interactions among factors.

Continuous Evaluation

To fully conserve the investment of time, money, and facilities, collating and calibration test programs must be continuously maintained to better relate the total service environment to the simulative methods being used.

To insure full value from new simulated service test methods, it is essential that, coincident with their use, there be means of relating test results to actual service. If this collating effort is delayed, it may never be undertaken and confusion and waste of money invariably result. Round-robin testing as well as full-scale field tests are useful tools in the collation process.

Certain kinds of continuing effort could do much in advancing the simulative service test toward the point of earlier, more timely, and more accurate results. For example, consider the following:

(a) A published compendium of problems where better solutions are highly desirable might lead to greater dispersion of effort and suggestions for solution.

(b) Published case histories of successful development of accelerated test methods might contribute to solution of related problems.

(c) Constant use of the statistical design of experiment approach can pay big dividends in relating simulated testing in the laboratory to field conditions.

The **Environmental Quarterly** assumes full responsibility for the fact that a photograph of a test chamber was printed upside down in the last issue in the International Radiant advertisement. This appearance was strictly in error and was in no sense intentional.

HANDBOOK OF THE ENVIRONMENT

(Continued from Page 27)

them as published at no extra cost. A limited number of copies of each volume will be available to the public at a price per volume to be established by the Joint Council of the IEE-EEI. This price was not firm in time for presentation in this issue. At the discretion of Dr. Wilkinson, certain non-profit organizations and university libraries will receive the Handbook free.

Sub-committee Chairmen-Editors Vital to Project

In a statement released to the press April 17, Mattingley emphasized the essential role in the production of each volume of the *Handbook* of the sub-committee Chairman-Editor and his sub-committee members. "These outstanding men are the productive force for the *Handbook*," Mattingley said. "Because of the vast labor involved, our project will stand or fall, depending upon them. We are rapidly enlisting the services of people highly qualified in their professions to head up and man these Handbook task forces."

Sub-committees thus far established are:

General Instrumentation: Chairman, Dr. Surosky, plus Fred Herman, Tenney Engineering, Inc., and Maurice H. Simpson, Environmental Branch, Frankford Arsenal; *Sand and Dust*: Chairman, James A. Pauly, Mgr., Environmental Res. Sect., Automotive Dept., Southwest Research Institute; *Acceleration*: Chairman, Howard C. Zintz, Chief Engineer, The Rucker Company;

Shock and Vibration: Chairman, Robert L. Stallard, Staff Engineer, The Martin Company (Denver); plus Gordon L. Getline, Design Specialist, Convair (San Diego); A. I. Dranetz, Vice-Pres. and Gen. Mgr. of Glennite Instru. Div. of Gulton Industries, and A. Orlacchio and George Hieber, also of Gulton; Donald K. Robertson, Head, R & D. Dept, The Martin Company (Orlando); Raymond G. Yaeger, Staff Engineer, Chrysler Missile Division; and John F. Clarke, Staff Engineer, The Martin Company, Denver;

Sunlight and *Rain*: Chairman, Askin; *Humidity*: Carl B. Yoder, United States Testing Company; *Low Temperature*: Chairman, Ken Sneden, Tenney Engineering, Inc.; *High Temperature*: Chairman, Peter Zukauskas, The Martin Company (Baltimore); *Ozone*: Chairman, Mark Sigismund, Environmental Test Sect., Pittman-Dun Lab, Frankford Arsenal; *Fungus*: Chairman, Joseph D. Campbell, St. Johns University and Burgoyne Lab.; *Explosion;* Chairman, G. W. Gerhardt, Chief, Atmospheric Deterioration Sect., Wright Air Development Center; *Nuclear Radiation*: Dr. T. C. Helvey, The Martin Company (Orlando); *Philosophy of Simulated Service Testing*: Seaman.

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LOCAL CHAPTER NEWS

(*Continued from Page 22*)

Boston Applies for Charter

BOSTON—The proposed Boston Chapter, headed by Robert J Graeff, Equipment Sales Co., has formally applied for charter, and approval is essentially only a formality awaiting a meeting of the National Executive Committee. At a Dec. 11, 1957, meeting, A. S. Richardson, Jr., MIT Aeroelastic & Structures Research Lab, presented a paper that appears in revised and condensed form as the lead article in this issue of the Quarterly (page 8).

On February 25, the group met at Barry Controls, Inc., where it heard discussions and saw demonstrations on "Shock Testing Instrumentation" presented by Messrs Lowe, Cavanaugh, Hines, and Lazarus, all of Barry Controls.

CHICAGO—This chapter has held 3 regular monthly meetings during the first quarter of 1958. *January* 22: Movie—"Horizons Unlimited—Viking Rocket." Paper—"Design Aspects of Vibration Fixtures" by Arthur Sorensen, Jr., and John D. Losse, both of A. C. Spark Plug Div of GM. *February* 19: Ernest Corduan, Vap-Air Co., Div. of Vapor Heating Corp., speaking on "Testing of Aircraft Temperature and Pressure Control Systems," including the Techniques and equipment required for simulated dynamic testing. *March* 26: Tour of Inland Testing Lab at the Technological Center of Cook Electric Co., conducted by Gerald Cannon. Included reliability, chemical, and general environmental labs, and the radiation cell.

New officers for the year April 1958 to March 1959 are:

President, Edward A. Feldmann, J. P. Seeburg Corp.;

Vice-President, Don A. Brosseau, Roth Mfg. Company;

National Director, Richard F. Hahn, Webcor Testing Laboratories;

Treasurer, Robert H. Jacobson, Armour Research Foundation; and

Secretary, William J. Carey, Murphy & Miller, Inc.

Space Environments Studied

NEW YORK CITY—Main event of a January meeting was a report on the "Hyper Environments" by R. A. Di Taranto and J. J. Lamb of RCA. Both Di Taranto and Lamb are Sr. Engineers, RCA Defense Electronics Products Division, Camden, N. J. The lectures were based on the first phase of a study by RCA for the Air Force of the environments expected to be encountered by missiles and satellites. The report included atmospheric conditions above 75,000 feet of vacuum, ozone, nitrogen decomposition, aura, magnetic deviation, and dynamic problems of acceleration, zero gravity, shock and vibration. It was shown that altitude simulation up to 450,000 feet will be required, that above 180,000 feet the transfer of heat is almost purely radiant, that shock temperatures from —53°C to —1,000°C within two minutes will be experienced, and that overall random noise pressures of 175 db, shock impulses to 75 G, and the possibility of X-rays, nitric oxide, ozone, and meteoric dust particles all will affect satellites and missiles.

The meeting began with a tour of the manufacturing facilities of Tenney Engineering, Inc., where climatic testing equipment was on display. Tenney is a member of the Environmental Equipment Institute.

Six-Story-High Drop Tester—"The Guillotine"

The March meeting featured a tour of the Material Laboratory of the New York Naval Shipyard. Among the high-lights of the tour were a six-story-high drop test elevator known as the "Guillotine," numerous hammer-type Navy Shock Machines, universal strength testers, Scorsby Tables that reproduce the motion of a

(*Continued on Page 33*)

NEW IEE MEMBERSHIPS

Since the last issue. Where home addresses are shown, company affiliations appear in parentheses.

MEMBERS

California

Arthur J. Sidrow (Hughes Aircraft Co.), 20301 Vose Street, Canoga Park
Richard E. Boone (Hughes Aircraft Co.), 4153 Motor Ave., Culver City
Robert S. Law-rie Hughes Aircraft Co., Florence & Teale Sts., Culver City
Seymour S. Uslan, Hughes Aircraft Co., Florence & Teale Sts., Culver City
Robert A. Whiting, Hughes Aircraft Co., Florence & Teale Sts., Culver City
Edward P. Peters (Hughes Aircraft Co.), 1024½ E. Hyde Park Blvd., Inglewood
George Traut, Jr. (Hughes Aircraft Co.), 3929 El Caminito, La Crescenta
George E. Dunlop (Hughes Aircraft Co.), 3621½ S. Sepulveda Blvd., Los Angeles
Robert J. Varga (Hughes Aircraft Co.), 4265½ Garthwaite Ave., Los Angeles
William H. Talbott, California Testing Lab., 619 E. Washington Blvd., Los Angeles
Harold Horton, The Rucker Co., 4700 San Pablo Ave., Oakland
Albert B. Roth, The Rucker Company, 4700 San Pablo Ave., Oakland
Clarence J. Woodward, The Rucker Company, 4700 San Pablo Ave., Oakland

Connecticut

Robert D. Matt, Equipment Sales Co., Inc., P. O. Box 6098, New Haven

Illinois

Richard G. Hagenauer, Minneapolis-Honeywell Regulator Co., P. O. Box 8530 A, 7350 N. Lincoln Ave., Chicago
Walter L. Dahl, Soreng. Div., Controls Co. of America, 9655 Soreng Ave., Schiller Park

Indiana

William O. Cook, P. R. Mallory Company, 3029 E. Washington St., Indianapolis

Massachusetts

Dante Rossi, Instrument Development Lab., Mechanic St., Attleboro
Bartholomew H. Healy (Technical Instruments, Inc.), 41 Pine St., Bedford
Abraham Osborn (Aerohm Corp.), Stillmeadow, Harvard
Paul W. Patton, N R C Equipment Corp., 160 Charlemont St., Newton Highlands

Michigan

Norman E. Havercraft (Chrysler Corp.), 8064 William, Dearborn

New Jersey

Uno C. Hedin (Ling Electronics, Inc), 2 Nottingham Rd, Short Hills

NOTE: We wish to apologize to Mr. Hedin for having inadvertently omitted his name from the last issue

Frank X. Klekotka Heinemann Electric Co., 610 Plum St., Trenton
Robert O. Norton, Standard Cabinet Co., 56 Washington Ave., Carlstadt
Arthur N. Purdy, Jr., General Testing Lab., 58 Washington Ave., Carlstadt
Ivan M. Silver, General Testing Lab., 58 Washington Ave., Carlstadt

(*Continued on Next Page*)

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MEMBER OF THE E.E.I.

(Continued from Proceeding Page)

George K. Sneden, Jr. (Tenney Engineering, Inc.), 487 Linden Place, Orange

Harvey H. Stewart, Jr. (Reaction Motors, Inc.), 150 Indian Rd., Pines Lake, Wayne

New York

Jack Rivlin (American Bosch Arma Corp.), 100 Garden Drive, Albertson

Martin P. Miller (Sonotone Corp.), 80 Van Cortland Pk. S., Bronx

John F. Fierro (American Bosch Arma Corp.), 3520—12th Ave., Brooklyn

Mitchel J. Guttentag (New York Testing Labs., Inc.), 820 Ave. Z, Brooklyn

Herbert N. Holtzer, American Bosch Arma Corp., Garden City

Julius Y. Liu, American Bosch Arma Corp., Garden City

John E. Monneret, American Bosch Arma Corp., Garden City

Robert H Rudkin, American Bosch Arma Corp., Garden City

William J. Reich, American Bosch Arma Corp., Garden City

William D. Salveson, American Bosch Arma Corp., Garden City

Robert F. Schumann, American Bosch Arma Corp., Garden City

John J. Sexton, American Bosch Arma Corp., Garden City

Lawrence Chandler (American Bosch Arma Corp.), 43 Villa Court, Hempstead

Thomas N. S. Shane (American Bosch Arma Corp.), 56 Colonial Ave., Mineola

Dean B. Arlidge, Consolidated Electrodynamics Corp., 1775 Mount Read Blvd., Rochester

Edward W. Jones (American Bosch Arma Corp.), 199-15 120th Ave., St. Albans

Hartland S. West, Burgoyne Testing Labs., Inc., 542 Main St., Westbury

Ohio

Robert Baggild, General Electric Co., Cincinnati

Pennsylvania

Raymond A. Stahl, Tele Dynamics Inc., 5000 Parkside Ave., Philadelphia

EDUCATOR MEMBERS

Joseph D. Campbell (Burgoyne Testing Labs., and St. Johns Univ.), 30 George St., East Hills, L. I., New York

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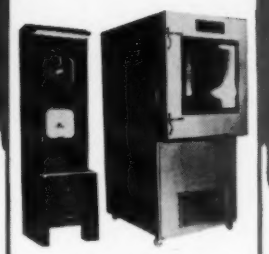

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LOCAL CHAPTER NEWS

(Continued from Page 30)

ship, sound generation equipment, anacoic chambers, and numerous climatic facilities at the All-weather Station. Albin M. Snadyc, Head of the Material Laboratory, presided as MC and described the unit's operation. Herman Reitman, Malfred Cohen, Robert Schwartz, and Murray Silverman, all of the Material Lab, answered the questions of the 97 persons present who helped make the meeting a success.

DETROIT — Fifty persons attended the April meeting of the Detroit Chapter to hear Robert H. Brown, Vice-President, Tenney Engineering, speaking on "New Trends in Environmental Laboratory Equipment." Bown pointed out that two of the main trends were in combining both high and low temperature extremes with vibration testing and high altitude testing. The trend in high altitude, he said, is to 150,000 feet and in temperature is from -200° F. to +1000° F. The group also viewed the Air Force movie, "Design for Environment."

Pilot run testing of electronic instrumentation for WADC is the subject of a new contract with the Environmental Test Lab of BJ Electronics, Borg-Warner Corp.

For ultrasonic immersion type of non-destructive testing, AVCO now operates a 256-cubic-foot ultrasonic tank facility in connection with its work as prime contractor for development of the AF Titan ICBM re-entry vehicle.

PET

(Continued from Page 15)

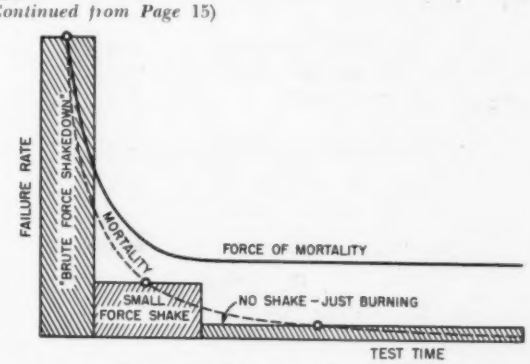

Figure 5. False infant mortality

single therapy. This also is a horrible mistake. Missiles, too, fail not just because of an "epidemic," or a "key" environment, such as vibration, but because of perhaps thousands of different "diseases." What about these? To ignore them is to play ostrich. Each one kills its share of missiles.

Mild Shaking

One more fallacy: It is widely believed that a "mild" shaking of all production items will not harm the "good" components but will help detect the "bad" ones. That concept, however, has also failed to improve reliability. Again the reasons are not difficult to find:

(Continued on Page 35)

NEW PRODUCTS

For more information, circle the key number on Reader Service Card.

1—Maker claims first shock machine developed to meet Spec. WS-107A-2, Environmental Test Requirements—Airborne Electronic Equipment. Designed to produce and reproduce saw-tooth wave shock patterns of above 100 G's over spectrum of 80 to above 1,000 cps. Provides terminal-peak pulse shape rising to 100 G's in 6 milliseconds and dropping abruptly to zero. Takes specimens to 40 lb. 2,000 lb. concrete base cradles impact anvil. Carriage impacts against molded lead pellets of various controlled shapes. On display at EEI Equipment Conference, Apr. 17-18, New Yorker Hotel, New York City. Lycoming Div., AVCO.

2—Portable temperature chambers with built-in fork lift especially designed for environmental testing with vibration machines. Permanently attached fork lift adjustable to fit up to a 2,500-pound force vibrator. Removable bottom and side panels for vertically or horizontally positioned vibration machines. Temp. range: —100° to +600°F. Tenney Engineering, Inc.

3—Portable shock machine for missile and aircraft components. Maker claims close control and exact repeatability. Specimens to 60 lb. Generates 100 G Ramo-Wooldridge missile test, as well as tests required by MIL specs. No special foundation for lab installation. Shock pulses from 2 milliseconds at up to 700 G peak acceleration to 60 milliseconds at up to 25 G peak. Makes use of rubber compression pads, conical lead pellets, and impact punching into lead bar for production of various shock impulse forms. Barry Controls, Inc.

4—Environmental test unit—for special testing of electronic parts—is factory adjusted to plus 77°F. Has 6 cu ft drawer-design chilling chamber (20" by 24" by 24"). Observation window and light in front wall. Accommodates 50-lb. batches. Net thermal capacity of about 300 B.T.U. per hour at plus 68°F. Refrigerant system is electronically leak tested. Cincinnati Sub-Zero Products.

5—Foil rosette strain gages for shock and vibration testing provide accurate data on rapidly varying states of stress. Also usable in studies of simulated thermally induced stresses such as are caused by supersonic plane and missile flight. Baldwin-Lima-Hamilton Corp.

6—Drop test machine provides shock forces above 77 G's on specimens to 400 pounds. Piston type platform falls free into a cylinder of air. Advantages claimed: Waveform repeatability and simplicity of operation. The Aeroflex Corporation.

7—General purpose vibration tester. Accurately indicates any of the 3 vibration parameters—displacement, velocity, or acceleration—by selecting proper position on mode or function switch. Six ranges of full-scale displacement. From 5 to 5,000 cps. Operates from a velocity pickup. Provides a direct measure of load displacement, velocity, and/or acceleration that is essential for meaningful tests. Ling Electronics, Inc.

8—Low-temperature chilling and refrigeration machine, 5 cu. ft. Maximum capacity in minimum floor space. Features economy and dependability. With its oil separator, oil filter, safety controls, and overload protection, the unit is completely automatic. Will withstand power failures without high pressure or loss of refrigerants. Harris Refrigeration Company.

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PET

(Continued from Page 33)

If the severity of test is mild, say, only 10 or 20 percent of the service severity, only very few marginal components will be detected and "screened out." The others remain undetected and may fail later in flight, killing the whole expensive missile.

And what about the many other environments and thousands of design criteria, that have nothing to do with vibration? PET neglects them entirely.

Whenever the mild-shake concept is challenged, the much maligned loose particles are inevitably brought up. Actually, they are very rarely the cause of a failure. Besides, aren't they best eliminated by the old-fashioned air jet hose, followed by a gentle tapping and tilting of the casing?

Initial vs. Long-Range Reliability

Production Environmental Testing is not only a fallacious but is also a short-sighted concept. It is aimed at improving the *initial reliability*, yet completely neglects *long-range* reliability, which is far more significant for the value of a military equipment, and far more difficult to achieve.

I recommended that existing Production Environmental Test programs be discontinued and that comprehensive Test-To-Failure programs be implemented instead.

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Test equipment for the following environmental conditions is ava'lable in the laboratory as follows:

VIBRATION:	600# force; 2000 cps
ACCELERATION:	50# @ 50 g's
SHOCK:	Per Spec. 7201
TEMPERATURE: & HUMIDITY:	200°F 100% R. H.
TEMPERATURE: & ALTITUDE:	−100°F to +200°F 100,000 ft.
HIGH TEMP.:	To 1,000°F
RAIN:	4" per hour
SUNSHINE:	Per MIL-E-5272A
EXPLOSION:	Per MIL-E-5272A
FUNGUS:	Per MIL-E-5272A
SALT SPRAY:	Per MIL-E-5272A
SAND & DUST	Per MIL-E-5272A

All environmental equipment is suitably instrumented with recording, indicating and controlling devices and fully complies with the requirements of the Military Specification MIL-E-5272A.

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Supplementing the normal services of an environmental test facility, Parameters, Inc. is a capable of functionally testing all components. Parameters, Inc. maintains a complete hydraulic electronic and mechanical test facility to provide a 'one-stop' testing organization.

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generator, phasemeter, servo valve
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FOR MORE INFORMATION ABOUT THE TESTING, ENGINEERING, DESIGN OR DEVELOPMENT FUNCTIONS OF PARAMETERS, INC., WRITE TO:

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